

# DOSIMETRIC PROPERTIES AND RADIATION HARDNESS OF THE STORAGE PHOSPHOR EUROPIUM DOPED POTASSIUM CHLORIDE FOR RADIATION THERAPY DOSIMETRY

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## ABSTRACT

This work establishes the photostimulable phosphor  $\text{KCl:Eu}^{2+}$  as a next generation radiation therapy dosimetry material. Prototype chip and panel dosimeters were fabricated in-house according to well-developed materials science processes. Dosimetric properties were studied by reading photostimulated luminescence (PSL) after irradiation with a laboratory optical system. The PSL signal decreased with time and stabilized to 0.1% decrease/h after 12 h. Sensitivity was independent of dose rate from 15 to 1000 cGy/min and also independent of beam energy for either open x ray or megavoltage electron fields. Over-response to low-energy scattered photons was comparable to radiographic film and was reduced by sandwiching the dosimeters between 0.3 mm thick lead foils during irradiation. An initially supralinear dose response became linear over the range of 100 to 700 cGy after cumulated doses of 60 Gy. Linearity was maintained up to 5000 Gy history. Sensitivity increased out to 3000 Gy history and then declined to 90% of zero-dose history value at 5000 Gy. There were no significant changes in the PSL stimulation, PSL emission, photoluminescence (PL) emission, or luminescence lifetime with dose history, indicating that the PSL process of irradiation, energy storage, excitation, energy transfer, and excitation and relaxation of the activator remained stable with dose histories up to 5000 Gy and that the material could be reused up to 2500 times at 2 Gy per use, as in, for example, patient-specific quality assurance.

The generation efficiency,  $W$ , of  $\text{KCl:Eu}^{2+}$  was determined to be 157 eV/ $h\nu$  and sub-millimeter spatial resolution was achieved for films 150  $\mu\text{m}$  thick. Monte Carlo simulations demonstrated that micron-thick  $\text{KCl:Eu}^{2+}$  films have a water-equivalent dose response and, given the measured  $W$ , would generate sufficient photoelectrons at the PMT photocathode for detection and amplification for delivered doses as low as a one cGy dose-to-water. PSL was routinely achieved for thin vapor-deposited  $\text{KCl:Eu}^{2+}$  panels less than 10  $\mu\text{m}$ , however signal stability measurements of thin panels revealed challenges related to moisture protection of the material that may require the application of protective coatings.

In summary,  $\text{KCl:Eu}^{2+}$  is demonstrated to have many desirable properties for radiation therapy dosimetry, such as reusability, a characterizable dose response, and, in the case of thin panels, water-equivalence. The results of this study provide a practical and theoretical knowledge base that supports future  $\text{KCl:Eu}^{2+}$  dosimetry research.